Vasantha Kalyani David and Sundaramoorthy Rajasekaran

Pattern Recognition Using Neural and Functional Networks

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Preface

Biologically inspired computing is different from conventional computing. It has a different feel; often the terminology does not sound like it's talking about machines. The activities of this computing sound more human than mechanistic as people speak of machines that behave, react, self-organize, learn, generalize, remember and even to forget. Much of this technology tries to mimic nature's approach in order to mimic some of nature's capabilities. They have a rigorous, mathematical basis and neural networks for example have a statistically valid set on which the network is trained.

Two outlines are suggested as the possible tracks for pattern recognition. They are neural networks and functional networks. Neural Networks (many interconnected elements operating in parallel) carry out tasks that are not only beyond the scope of conventional processing but also cannot be understood in the same terms. Imaging applications for neural networks seem to be a natural fit. Neural networks love to do pattern recognition. A new approach to pattern recognition using microARTMAP together with wavelet transforms in the context of hand written characters, gestures and signatures have been dealt. The Kohonen Network, Back Propagation Networks and Competitive Hopfield Neural Network have been considered for various applications.

Functional networks, being a generalized form of Neural Networks where functions are learned rather than weights is compared with Multiple Regression Analysis for some applications and the results are seen to be coincident.

New kinds of intelligence can be added to machines, and we will have the possibility of learning more about learning. Thus our imaginations and options are being stretched. These new machines will be fault-tolerant, intelligent and self-programming thus trying to make the machines smarter. So as to make those who use the techniques even smarter.

Chapter 1 is a brief introduction to Neural and Functional networks in the context of Pattern recognition using these disciplines **Chapter 2** gives a review of the architectures relevant to the investigation and the development of these technologies in the past few decades.

Chapter 3 begins with the look at the recognition of handwritten alphabets using the algorithm for ordered list of boundary pixels as well as the Kohonen Self-Organizing Map (SOM). **Chapter 4** describes the architecture of the MicroARTMAP and its capability.

Chapter 5 the MicroARTMAP is augmented with a moment based feature extractor and applied to character recognition in this chapter. **Chapter 6** illustrates the use of wavelet transforms together with MicroARTMAP for character recognition. The microARTMAP gave solutions to problems in civil engineering like classification of soil problem, finding the load from yield pattern of a plate and finding earthquake parameters from a given response spectrum.

Chapter 7 MicroARTMAP and Back Propagation Network have been compared and presented for gesture recognition and signature verification. Solving scheduling problem by means of a Competitive Hopfield Neural Network are discussed in **Chapter 8** Multiple Regression methods considered as a recognizer is compared with functional networks in solving certain problems as shown in **Chapter 9.** Conclusion and further applications are suggested in **Chapter 10**.

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List of Notations

ε - belongs to
  - strain
<, = , > - either less than or equal to or greater than
∀ - for all
|.| - fuzzy count
∧ - fuzzy intersection
∨ - fuzzy union
⇒ - implies
∫ - integral
⊕ - includes operator
∩ - intersection operator
| | - modulus operator
| p | - norm of p given by $\sum_{i=1}^{n} p_i$ where p = (p_1,p_2, ...,p_n)
τ - shear strength
σ - normal stress
Σ - summation
∪ - union vector
∫∫ - double integral
[0, 1] - closed interval between 0 and 1
$[0, 1]^n$ - fuzzy n-cube
a - approximate signal
a^c - fuzzy complement of a, i.e., a = 1-a
A - vector
A′ - normalized vector of A
ART^a - fuzzy ART module
ART^b - fuzzy ART module
BLU - basic length unit
  - Lead screw pitch / number of revolutions
C - Cohesion intercept
CWT - continuous wavelet transforms

$C_1, C_2, C_3, C_4, C_5, C_6$ - refer to weighting factors

$$C(a, b) = \int_{-\infty}^{+\infty} f(x)\, \psi_{a,b}(x)\, dx$$

gives wavelet co-efficients

$$C A_N(k) = \int_{-\infty}^{+\infty} f(x)\, \psi_{N,k}(x)\, dx$$

gives approximate co-efficients

$$C D_N(k) = \int_{-\infty}^{+\infty} f(x)\, \psi_{N,k}(x)\, dx$$

gives detailed co-efficients

d - detailed version

d - Euclidean distance

DWT - discrete wavelet transforms

e_j - error in the j^{th} data

$e_j = f_i(x_{ij}) + f_2(x_{2j}) - f_3(x_{3j})$

E - Young's modulus

E - Number of times stepper motor has to be energized

E - Energy function

E - Euclidean norm of error function

$$E = 1/2 \sum_{i=1}^{n} \left(O_i - F(i)\right)^2$$

E - sum of the squares of the error for all data

$$E = \sum_{j=1}^{n\ data} e_j^T\, e_j$$

E_p - plastic modulus

E_p - entropy of parent node

E_A, E_H, E_V, E_D - entropy of four offsprings. Approximation, horizontal, vertical and diagonal details

E(f) - additive cost function

- approximate neural function

$$f_i(x) = \sum_{j=1}^{m} a_{ij} \phi_{ij}(X)$$

F^{ab} - map field

$F_1 \rightarrow F_2$ - mapping from F_1 to F_2

f_n - cyclic frequency

g(n) - high pass filter

h - hamming distance

h_j - contribution to H of set A_j

h_{max} - upper bound on h_j

$h(n)$	-	low pass filter
H	-	conditional entropy
H_{max}	-	upper bound on H
$H(G_{ijk})$	-	heavside function
$H(B/A)$	-	conditional entropy
m_{pq}, $p, q = 0, 1, 2, \ldots, n$	-	moment transformation
M	-	mass
	-	earthquake magnitude
M	-	minimum step angle
M	-	total number of machines
M, R, S, H	-	Magnitude, Site condition, Focal depth, Epicentral distance from response spectrum
m	-	strain rate sensitivity index
N	-	total number of processes
Net_{ijk}	-	total input to the neuron (i, j, k)
n	-	strain hardening exponent
P_i	-	total execution time required by a process
R	-	required angle
R	-	augmented function $R = E + \langle \underline{a} \rangle [\phi_0] \{\lambda\} - \langle \lambda \rangle \{\alpha\}$ $R = \langle \underline{a} \rangle [A] \{\underline{a}\} + \langle \underline{a} \rangle [\phi_0] \{\lambda\} - \langle \lambda \rangle \{\alpha\}$
R_{is}	-	process i requires resource s
t	-	thickness of the plate
T	-	maximum time quantum of a process
T_j	-	choice function
T_n	-	natural vibration period
V_{ijk}	-	state variable representing whether or not a job i is executed on a machine j at a certain time k
W_{new}	-	updated weight vector
W_{old}	-	old weight vector
W_{xyzijk}	-	synaptic interconnection strength
W_φ, W_ψ^H, W_ψ^V and W_ψ^D	-	quarter size output subimages
$x(n)$	-	original signal

$$x(n) * h(n) = \sum_{k=-\infty}^{+\infty} x(k) * h(n-k)$$

convolution operation

$y_{high}(k)$	-	output of high pass filter
$y_{low}(k)$	-	outputs of low pass filter
α	-	choice parameter
	-	material thermal constant
β	-	learning rate parameter
$\delta(a,b)$	-	Kronecker delta function
ϕ	-	shape functions $(1, x, x^2, \ldots, x^n)$ or (1, sin(x), cos(x), sin(2x), cos(2x), sin(3x), cos(3x)………)
	-	angle of internal friction

$\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6, \phi_7$	-	invariant functions
η_{pq}	-	normalized central moments
$\varphi\,(x, y)$	-	two dimensional scaling function
$\varphi_{j, m, n}\,(x, y)$	-	scaled basis function
μ_{pq}	-	central moments
μARTMAP	-	microARTMAP
ν	-	Poisson ratio
θ_{ijk}	-	bias input
ρ	-	vigilance parameters
σ_0	-	yield stress
$\psi(x)$	-	wavelet function
$\psi(u)$	-	Fourier transform
$\psi_{a, b}\,(x)$	-	mother wavelet generates basis functions
$\psi^D\,(x, y)$	-	variations along diagonals
$\psi^H\,(x, y)$	-	variations along columns (horizontal)
$\psi^V\,(x, y)$	-	variations along rows (vertical)
$\psi^i_{j, m, n}\,(x, y)$	-	translated basis function
ω_n	-	circular frequency
$\dfrac{\partial(\,)}{\partial(\,)}$	-	partial derivative
2/3 rule	-	two out of possible three inputs are active